Amendments to the Specification

Please amend the paragraph beginning on page 4, line 8, as follows:

In order to obtain adequate depth of focus with improved resolution, phase-shift reticles are often used. To most effectively use a phase-shift reticle, the ratio σ between the NA of the illuminating optical system ~~NA~~ and the NA of the imaging optical system ~~NA~~ should be variable. An aperture stop can be installed in the imaging system to provide or increase this variability. But, in a catadioptric imaging system, as, for example, in U.S. Patent No. 4,779,966, there is often no location for an effective aperture stop

Please amend the paragraph beginning on page 4, line 17, as follows:

In catadioptric optical systems in which a double-pass lens system is employed in a demagnifying portion of the optical system, the demagnification reduces the allowable distance between the reflecting element and the wafer, so that few lenses can be placed in the optical path between the reflective element and the wafer. This necessarily limits the numerical aperture (NA), and thus the maximum brightness, of the optical system. Even if it were possible to realize an optical system with a high NA, many optical elements would have to be placed along a limited ~~optical path~~ optical-path length, so that the distance between the wafer and the ~~tip~~ nearest surface of the ~~object~~ objective lens (i.e., the working distance WD) would be undesirably short.

Please amend the paragraph beginning on page 5, line 8, as follows:

The applicant has previously proposed a dual-imaging optical system which is designed with a first imaging system comprising a two-way optical system having a concave mirror and a double-pass lens group that allows light both incident to, and reflected from, the concave mirror to pass through the lens group. An intermediate image is formed by the first imaging ~~system and~~ system, and an image of the intermediate image is formed by a second imaging system. A reflecting surface is provided to direct the light flux from the first imaging system toward the second imaging system.

Please amend the paragraph beginning on page 5, line 19, as follows:

This dual-imaging optical system allows a ~~smaller diameter~~ smaller-diameter concave mirror, and provides an effective aperture-stop placement position, allowing a variable ratio ~~σ based~~ σ, based on the NA of the illuminating optical system ~~NA~~ and the NA of the imaging ~~system NA~~ system, for use with phase-shift reticles for resolution enhancement. It also allows for sufficient ~~optical system~~ optical-system brightness and an optical system where the working distance WD, the distance between the wafer and the nearest surface of the ~~object imaging~~ object-imaging system (objective lens), can be relatively long. It also makes the adjustment of the eccentric section of the optical system easy, enabling the practical realization of a precision optical system.

Please amend the paragraph beginning on page 6, line 3, as follows:

While this dual-imaging optical system has many superior features, attempts to reduce the size of the optical system while maintaining image-forming performance ~~results~~ result in increased distortion. That is, the optical system is not symmetric, so even if other aberrations are corrected, distortion will remain.

Please amend the paragraph beginning on page 8, line 13, as follows:

In order to correct distortion or astigmatism, correct accumulated manufacturing tolerances, and not create other types of distortion, a correcting optical system in the form of at least one aspheric optical surface is placed near the intermediate image. The placement of an aspheric correcting optical system near the intermediate image is especially effective for correcting higher-order distortion or astigmatism. A lens with an aspheric surface may be used for this purpose. On the other hand, since the reflecting surface is near the intermediate image, the reflecting surface itself may be made aspheric and used as the correcting optical system. The reflecting surface can be placed very close to or even at the intermediate image, so that making the reflecting-surface aspheric allows ~~designating~~ designation of the desired distortion or ~~astigmatic aberration~~ astigmatic-aberration correction in a straightforward manner, with little effect on other types of aberration.

Please amend the paragraph beginning on page 9, line 3, as follows:

The aspheric surface is preferably axially symmetric. Alternatively, an aspheric lens surface could be combined with a rectangular reflecting surface shaped so that change ~~occurred~~ occurs only longitudinally in the reflecting surface. For the same sort of effect, the aspheric lens surface can be a circular or non-circular cylindrical (toric) surface. In other words, the effect that the shape of the aspheric surface has on distortion would be primarily dependent upon changes in the longitudinal inclination of the aspheric surface, and changes in the inclination in the shorter direction would not change the image height significantly, so it would not have that great an effect on distortion. A completely asymmetric aspheric surface may also be used as a lens surface or a reflecting surface.

Please amend the paragraph beginning on page 9, line 23, as follows:

An axially symmetric aspheric surface may be produced by performing ~~aspheric surface~~ machining of a surface symmetrically around the optical axis. A circular or non-circular cylindrical surface may be reproduced with a single-direction ~~aspheric surface machining~~ aspheric-surface-machining device.

Please amend the paragraph beginning on page 10, line 1, as follows:

When there are different levels of aberration across the image surface due to manufacturing error, a completely asymmetric aberration-correction surface can be used, depending upon the amount of aberration. Naturally, ~~it~~ the surface would be placed close to the intermediate image, so that just the corrections pertaining to the angle of view could be prioritized as necessary.

Please amend the paragraph beginning on page 11, line 4, as follows:

FIG. 3 is an optical diagram of the catadioptric reduction optical system of Example Embodiment 1, employing in the imaging system B a lens element L having an aspheric surface.

Please amend the paragraph beginning on page 11, line 8, as follows:

FIG. 4 is an expanded ~~optical path~~ optical-path diagram of Example Embodiment 1.

Please amend the paragraph beginning on page 12, line 20, as follows:

By way of example, the projection-optical system of FIGS. 1(a)-1(c) is a lens system with a magnification ratio of 1/4×, an image-side numerical aperture NA of 0.6, a maximum object height of 72 mm, and a rectangular aperture a. The rectangular aperture corresponds to a rectangular illumination field, with a vertical length of 120 mm. The refractive lenses can be made of fused silica (SiO_2) or calcium fluorite (CaF_2). At the 193-nm wavelength from an ultraviolet excimer laser, the chromatic axial and magnification ~~aberration is~~ aberrations are corrected for wavelength widths of ±0.1 nm.

Please amend the paragraph beginning on page 13, line 4, as follows:

FIGS. 2(a)-2(c) show a schematic diagram of a second representative embodiment, in which a reflecting surface M_3 is placed inside the second imaging system B, and the direction of travel of the light illuminating the reticle R is aligned with the direction of travel of the light exposing the wafer W. Other aspects of this embodiment are the same as for the first embodiment, and as such, ~~it~~ the second embodiment has the same imaging performance as the first embodiment.

Please amend the paragraph beginning on page 13, line 15, as follows:

FIG. 3 shows an ~~optical path~~optical-path diagram of Example Embodiment 1 of a catadioptric optical system according to the present invention. As shown in FIG. 3, an excimer laser E is configured to illuminate the reticle R. The optical system of FIG. 3 can be used with the respective embodiment of FIGS. ~~1(a)-1(c)~~ 1(a)-1(c) or ~~2(a)-2(c)~~ of FIGS. 2(a)-2(c). In FIG. 3, the reflecting surface M_2 is ~~planar~~ planar, and the surface of lens element L in the optical system B nearest to the reflecting surface M_2 is aspheric.

Please amend the paragraph beginning on page 13, line 22, as follows:

FIG. 4 shows an expanded ~~optical path~~ optical-path diagram of Example Embodiment 1. That is, in order to avoid the complications of reflected light in the drawings, the light rays are shown in ~~Fig.~~ FIG. 4 as always propagating in the same direction.

Please amend the paragraph beginning on page 13, line 27, as follows:

Table 1 below lists the surface data of Example Embodiment 1. The optical path of FIG. 4 is ~~taken~~ set forth in ~~Table 1,~~ Table 1 with the reflecting surface M_3 ~~omitted,~~ omitted and with a flat reflecting surface inserted, as surface 10, to represent the unfolding of the optical path as shown in FIG. 4. In Table 1, the first column lists the surface number from the reticle ~~R,~~ R; the second column, labeled ~~"r,"~~ "r", lists the radius of curvature for each of the ~~surfaces,~~ surfaces; the third column, labeled ~~"d,"~~ "d", lists the axial distance from each surface to the adjacent ~~surface,~~ surface; the fourth column lists the material for each ~~lens,~~ lens; and the fifth column lists the group designation for each optical element. The lens surface featuring an asterisk (*) in the first column is aspheric. An asterisk in column 5 indicates a return path.

Please amend the paragraph beginning on page 15, line 9, as follows:

FIGS. 5(a), 5(b), 5(c), 5(d), and 5(e) depict representative plots of spherical aberration, astigmatic aberration, distortion, coma, and magnification aberration exhibited by Example Embodiment 1. In FIG. 5(a), SC represents deviation from the sine condition. Also, in each of FIGS. 5(a)-5(d), Y is the image height, P is the standard wavelength +0.1 nm, J is the standard ~~wavelength~~ wavelength, and Q is the standard wavelength -0.1 nm. As is clear from each of FIGS. 5(a)-5(e), spherical aberration, coma, astigmatism, and distortion are all corrected to a very high degree, demonstrating the superior performance of this optical system.

Please amend the paragraph beginning on page 18, line 21, as follows:

FIG. 6 shows an optical path diagram of Example Embodiment 2 of a catadioptric optical system according to the present invention. The optical system of FIG. 3 can be used with the ~~embodiment~~ respective embodiment of FIGS. 1(a)-1(c) or of FIGS. 2(a)-2(c). In FIG. 3, the reflecting surface M_2 is ~~aspheric~~ aspheric, and the optical surface of lens L in the optical system B nearest to the reflecting surface M_2 is spherical.

Please amend the paragraph beginning on page 19, line 1, as follows:

Table 3 below lists the surface data of Example Embodiment 2. An optical path corresponding to FIG. 1 is ~~taken~~ set forth in Table 3, ~~so that~~ with the mirror M_3 ~~is~~ omitted. As in Table 1, in Table 3,

the first column lists the surface number from the reticle ~~R,~~ R; the second column, labeled ~~"r,"~~ "r", lists the radius of curvature for each of the ~~surfaces,~~ surfaces; the third column, labeled ~~"d,"~~ "d", lists the axial distance from each surface to the next ~~surface,~~ surface; the fourth column lists the material for each ~~lens,~~ lens; and the fifth column lists the group designation for each optical element. The surface featuring an asterisk (*) in the first column is aspheric. An asterisk in column 5 indicates a return path. In contrast with Table 1, negative distances (rather than negative radii of curvature) are employed in Table 3 to represent the return path of reflected light ~~rather than negative radii of curvature~~. In Table 3, surfaces 1-6, 13, and 26-31 are virtual surfaces that were considered as part of the lens-design process.

Please amend the paragraph beginning on page 19, line 18, as follows:

The shape of the aspheric surface of Example Embodiment 2 may be represented by the equation presented above relative to Example Embodiment 1. The conic coefficient κ and the aspheric surface coefficients for Example Embodiment 2 are shown in Table ~~4,~~ 4 (entitled Example Embodiment 2 Aspheric Surface Data), below.